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NCERC Capabilities

Joetta Goda, NEN-2

March 2, 2021



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National Criticality Experiments Research Center

NCERC is our nation's only general-purpose critical experiments facility and is one of only a few that remain operational throughout the world

- Large quantities and variety of SNM enable both critical experiments and unique static subcritical experiments.**
- Directly Contributing to Important National and International Missions**
- Making Investments in Pipeline and the Facility for enduring capability and expanding missions**



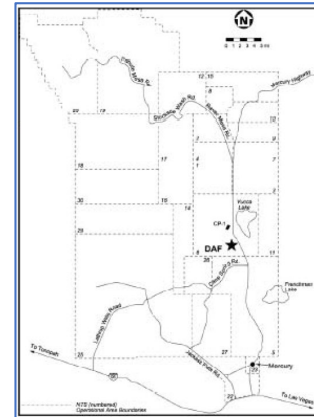
NCERC is our nation's only general-purpose critical experiments facility and is one of only a few that remain operational throughout the world

Location: Device Assembly Facility (DAF) at the Nevada Nuclear Security Site (NNSS)

Operated by: Los Alamos National Laboratory

NCERC Mission Statement:

The mission of the National Criticality Experiments Research Center (NCERC) is to conduct experiments and training with critical assemblies and fissionable material at or near criticality in order to explore reactivity phenomena, and to operate the assemblies in the regions from subcritical through delayed critical. One critical assembly, Godiva-IV, is designed to operate above prompt critical.



Our Critical Experiment Capability dates back to the Manhattan Project

- **1943-1945: Dragon Experiment and Water Boilers at Omega Site (LOPO, HYPO)**
- **1945: Daghlian criticality accident at Omega Site**
- **1946: Los Alamos Critical Experiments Facility (LACEF) founded at Pajarito Site (TA-18) at LANL**
- **1999: Decision made to move LACEF**
 - New Location: Eventually decided upon the DAF at NNSS (formerly NTS)
- **2004: First material shipment to the DAF**
- **2007: Subcritical mass measurements started at DAF**
- **2011: Approved to start critical operations, Planet first critical in June.**

Capability consists of decades of experience both in science and operations.

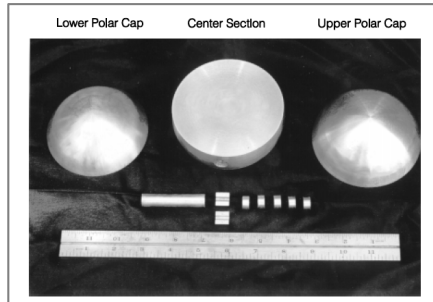


The available inventory of SNM enables unique measurements and experiments

- Extensive inventory of nuclear material
- Can be used for critical experiments on the critical assembly machines
- And can be used to construct high neutron multiplication, static objects referred to as Radiation Test Objects (RTOs) and Inspection Objects (IOs).



Two high bays
buildings for
subcritical
measurements



Thor core
9.6 kg delta-phase Pu-239



BERP Ball
4.5 kg alpha-phase Pu (94 wt% Pu-239)

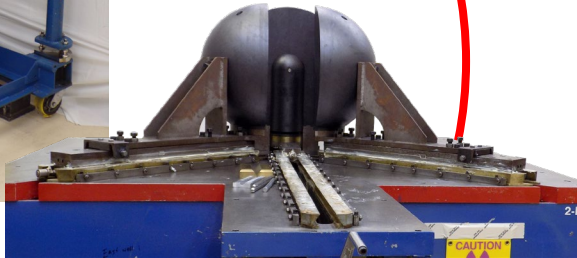


Rocky Flats shells
Metal HEU nesting hemispheres

There are four critical assembly machines located in two assembly cell buildings.



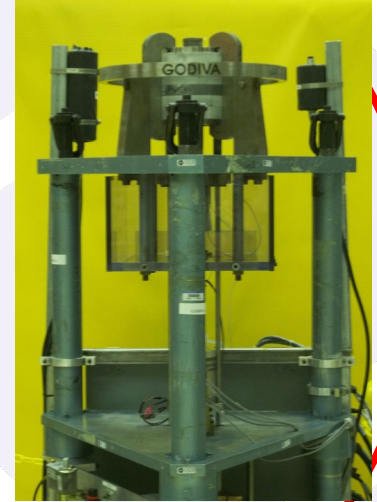
Planet



Flat-Top



Comet



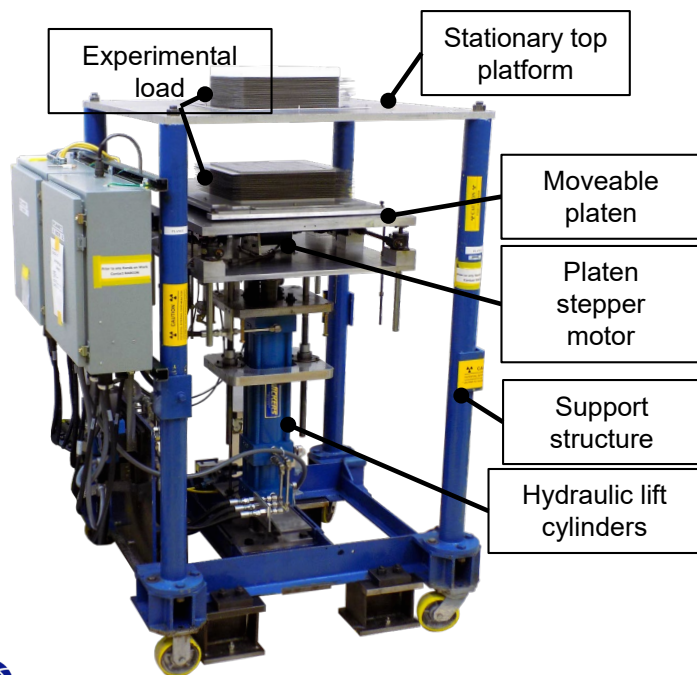
Godiva IV

Can only operate one per building at a time.



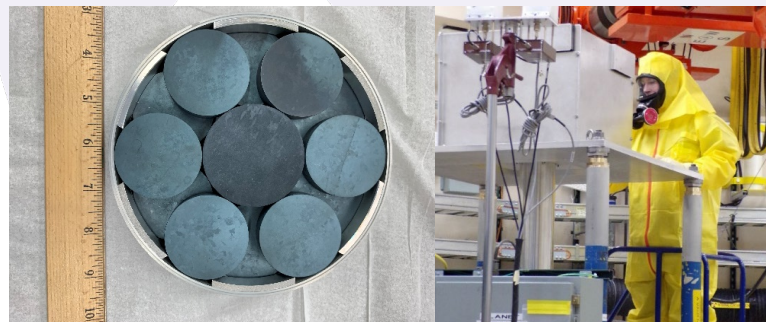
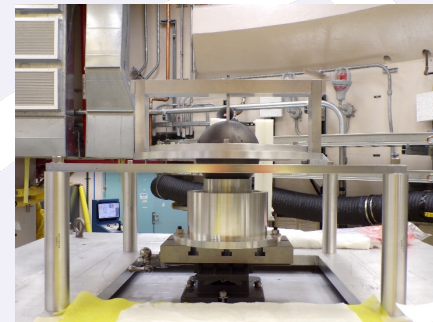
Planet

A general-purpose, light-duty vertical-lift assembly designed for flexibility in conducting critical experiments.



- Criticality Safety Training
- International Criticality Experiments Benchmark Evaluation Project
- NTNF irradiations

MUSIC: subcritical and critical configurations.



Yttrium Hydride before canning and the Hypatia experiment on Planet for DOE-NE.

March 2, 2021



Comet

A general-purpose, *heavy-duty* vertical lift assembly designed for flexibility in conducting critical experiments.

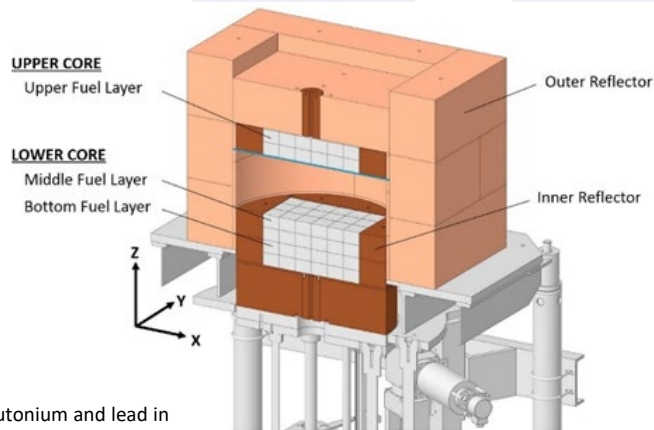


CURIE: Uranium and Teflon to test unresolved resonance region.

- JAEA U-Lead and Pu-Lead
- NASA KRUSTY/Kilopower
- NTNF foil irradiations
- ICSBEP Benchmark Evaluations



TEXHEU: Uranium and poly, designed to add Hafnium.



Jupiter: Plutonium and lead in collaboration with NA-23 and JAEA.

KRUSTY collaboration with NASA



Flattop

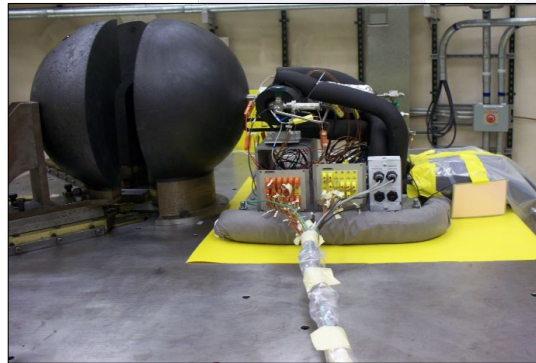
A fast spectrum benchmark critical assembly designed to demonstrate fundamentals of reactor physics and used as a general-purpose radiation source

1000 kg natural uranium reflector

500 kg hemisphere and two 250 kg quarter-sphere safety blocks

Interchangeable U-235 and Pu-239 cores

Glory hole for mass adjustment, samples, activation foils, etc.



Demonstration Using Flat-Top Fissions (DUFF) with NASA



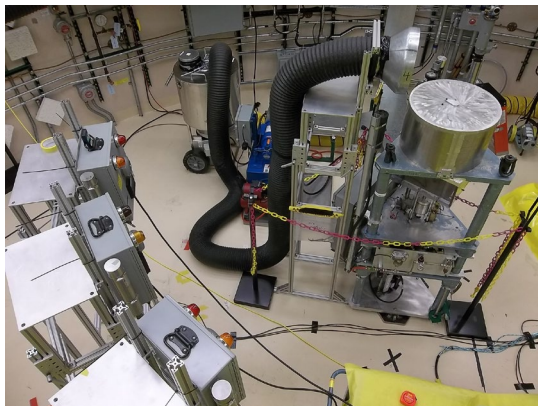
Fission/activation foil and fission chamber installation.

- Criticality Safety Training
- Nuclear Forensics
- Irradiations
- NASA DUFF
- Sample replacement measurements

Godiva IV

A critical assembly designed to operate above prompt-critical to provide intense, short bursts of neutrons.

- Cylindrical 65 kg, 93% enriched uranium, alloyed with 1.5% Mo for strength
- Criticality Safety Training
- Dosimetry Intercomparison
- Criticality Alarm Testing
- Multi-physics measurements



Y-12 Criticality Accident Alarm Systems (CAAS) around Godiva

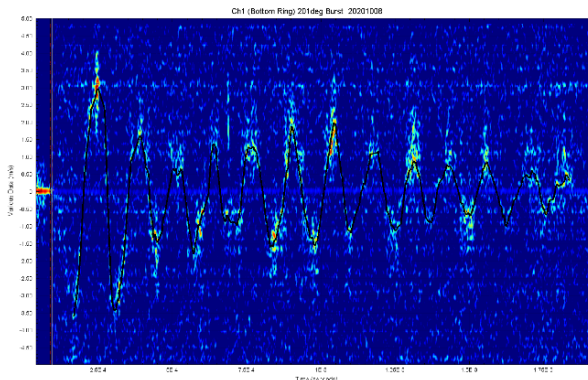
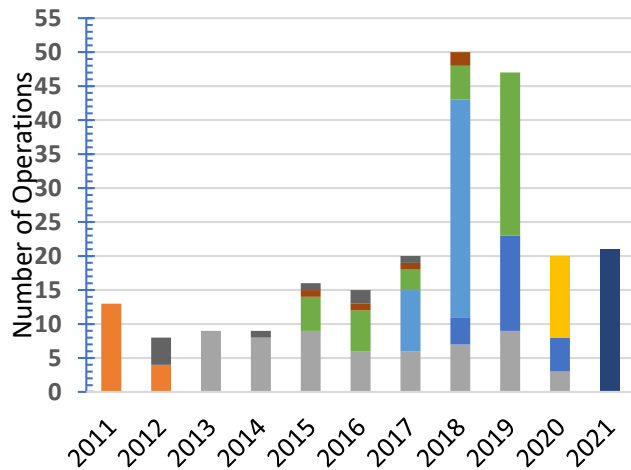


Photo-Doppler Velocimetry response on fuel surface during Godiva burst.

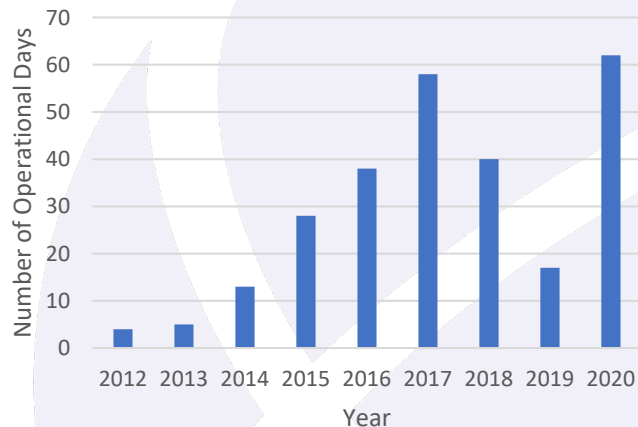
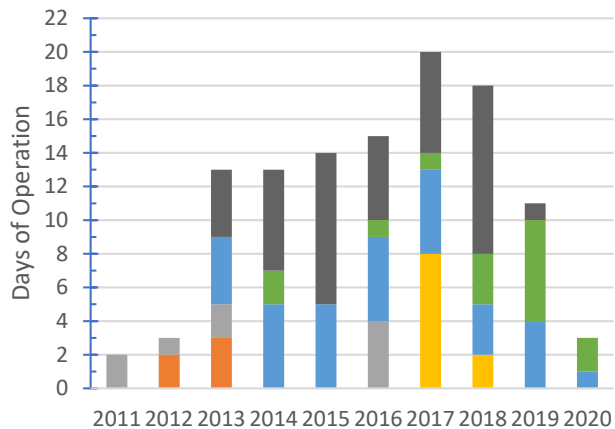


NCERC has now been operating for a decade

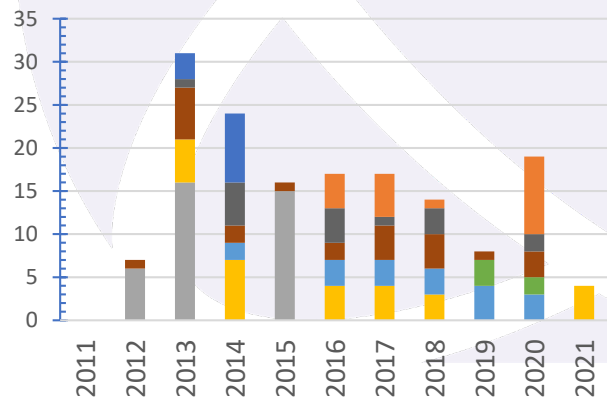
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Flat-Top



Comet

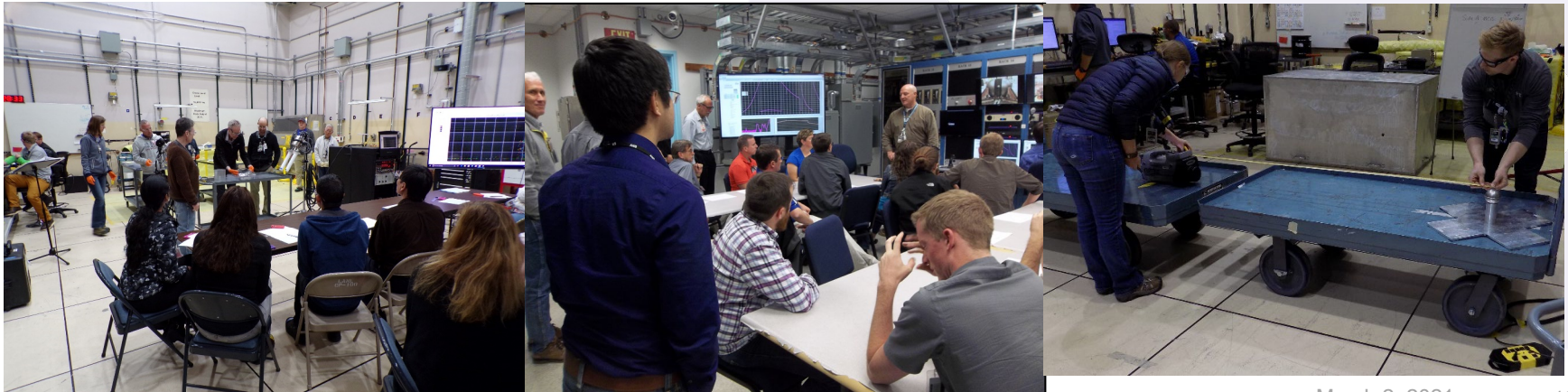


Godiva



Our Criticality Safety Courses provide a 'hands-on' experience that make concepts memorable

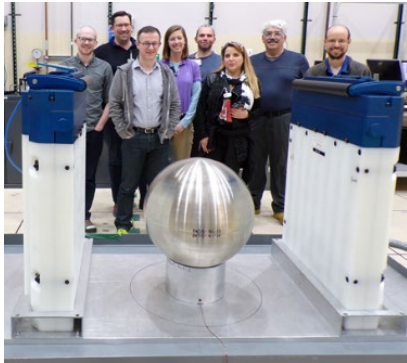
- **NCSP Two-Week Hands-On Criticality Safety Courses**
 - Focus on DOE Criticality Safety Engineers, Officers, and Managers
 - First week is classroom training and the second week is hand's-on demos and experiments at NCERC.
- **PF-4 Classes** – focus on Operators and Process Supervisors
- **Nuclear Emergency Support Team Classes**



Our courses are sought out across the national complex

The variety of SNM enables unique static subcritical experiments for a diverse mission set.

Neptunium Subcritical Observation (NESO)
Collaboration with IRSN (France)

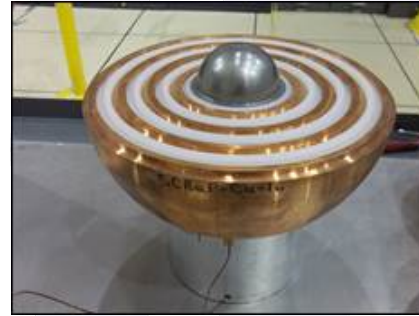


The Np Sphere, surrounded by a thick nickel reflector. The experiment team is behind.

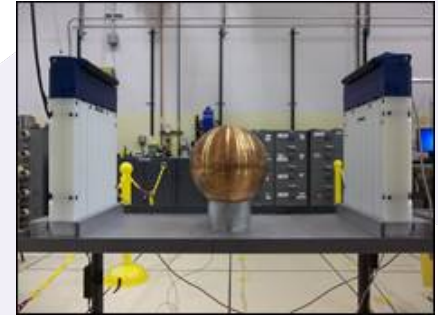


Gamma and neutron detectors measuring the sphere.

Subcritical Copper-Reflected alpha-phase Pu (SCRaP)
Subcritical benchmark included in the ICSBEP handbook



SCRaP Experiment with BeRP Pu Core

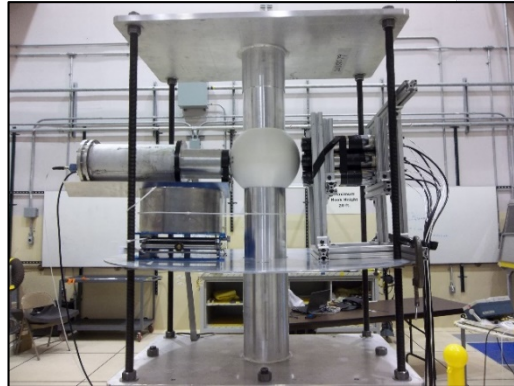


SCRaP Experiment Measurement



NCERC supports Neutron Diagnosed Subcritical Experiments (NDSE) by providing high-mass SNM objects for diagnostic development.

The NDSE Campaign has been ongoing at NCERC since 2016. These experiments support the NNSA Stockpile Stewardship mission. This support includes fissionable material handling, nuclear material transportation, and secure field operations.



Liquid scintillator measurements



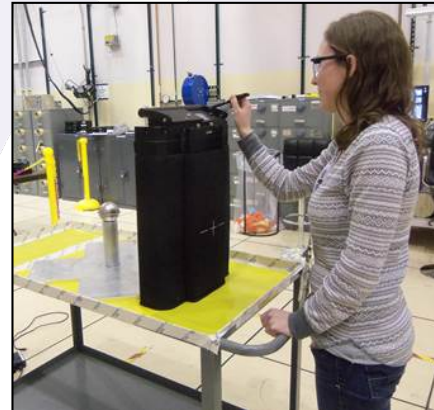
Inspection Object placement at Area 11 Test Stand



We are investing in the future of the workforce.

NA-22 funded University Consortia


- Provide collaborations between University research groups and Laboratory technical staff members
- Provide unique opportunity for SNM detection system testing at NCERC on subcritical RTOs (Pu, HEU, Np)
- Current consortia are Consortium for Monitoring Technology and Verification (MTV), Consortium for Enabling Technologies and Innovation (ETI), and Nuclear Science and Security Consortium (NSSC)



We are investing in the modernization of control systems.

- Critical Assembly Control Systems have been operational for 10+ years.
- NCERC Controls Upgrade Project developed Requirements and Criteria Document in FY20
- Capability Based Investments (CBI) Funding to initiate design and procurement of upgrades to NCERC Control Systems.












Los Alamos
NATIONAL LABORATORY
805-845-6000

**Conduct of Engineering
Requirements and Criteria Document**


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Project ID: Project Title: TA-82-DAF NCERC Controls
 DCF No.: DCF-20-82-DAF-3345 DCF Title: TA-82-DAF NCERC Controls
 TA: 82 Facility No.: DAF Facility Name: National Criticality Experiments Research Center (NCERC)

Facility Hazard Category: HazCat 2 Nuclear

Project Engineer:		AMY GITMICK	
Name	Z Number	Organization	Signature
Amy Gitmick	327386	ES-EPO	
Facility Design Authority Representative:		RYAN D LECOUNT	
Name	Z Number	Organization	Signature
Ryan LeCounte	285913	NCERC-FO	
Quality Assurance Subject Matter Expert:		GREGORY W. KNOX	
Name	Z Number	Organization	Signature
Greg Knox	236137	IQPA-IQ	
Facility Engineering Manager:		ALEXANDER R. LYNN	
Name	Z Number	Organization	Signature
Alex Lynn	282011	NCERC-FO	
Project Owner Representative:		JOETTA GODA	
Name	Z Number	Organization	Signature
Brian Blum	165903	NEH-2	
Safety Basis:		JAMES M. STRELOW	
Name	Z Number	Organization	Signature
James Strow	262943	KMP-FOCI	
Project Manager:		KAREN BOROVINA	
Name	Z Number	Organization	Signature
Karen Borovina	304708	WIPO	

Security Classification Review

Name	Z Number	Organization	Signature	Date
David Hayes	116798			9/10/2020

(Reviewed By) (Date) (Classification)

LANL David Kirk Hayes Digitally signed by David Kirk Hayes Date: 2020.09.16 09:13:33 -0700

AP-341-802-TMP01, Rev. 2 Effective Date: 04/23/2017



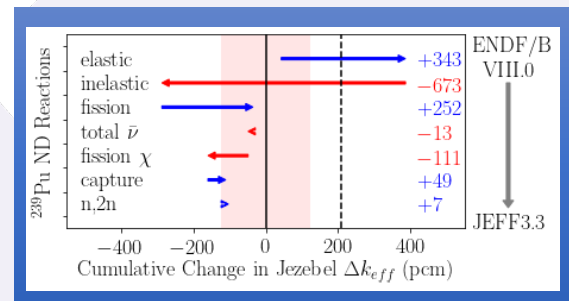
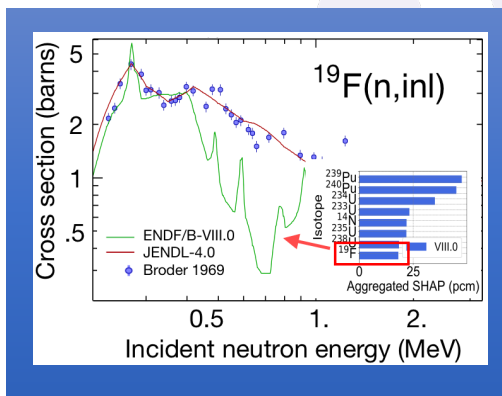
FY21 Laboratory Investment in Developing Roadmap

- **Background:** The next generation of civilian nuclear technologies—especially small modular reactors (SMRs) and micro nuclear reactors (MNRs)—can advance the US national security mission by providing reliable, resilient power of certain military installations; powering advanced weapons systems; reinvigorating the nuclear supply chain; and supporting nonproliferation goals.
- **Objective:** A national nuclear testbed for unique problems at the intersection of national security, criticality safety, and nuclear energy.
- **Problem:** Existing infrastructure is not adequate to support both enduring missions and this emergent mission space.
- **Approach:** Develop a roadmap to align infrastructure requirements with programmatic needs and cultivate the integrated support necessary to fund the resultant capability.



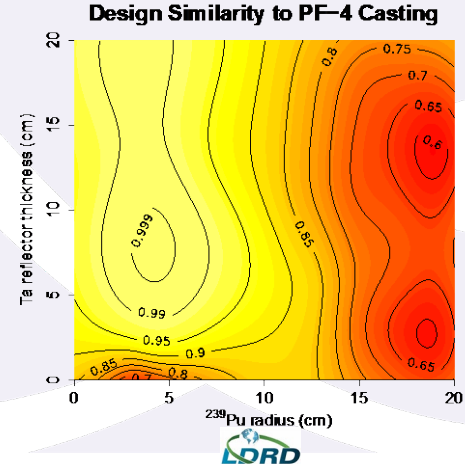
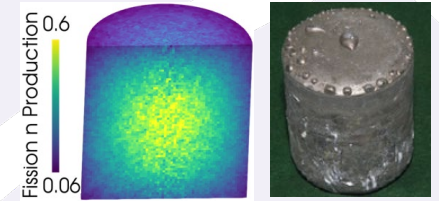
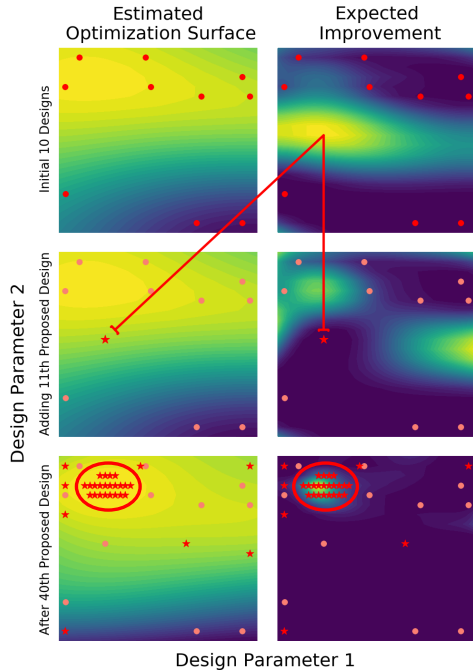
LDRD is investing in experiment optimization capability.

- EUCLID is an LDRD-DR Project to use Machine Learning to optimize experiment design.
- ARCHIMEDES was a predecessor LDRD Reserve Project that showed Machine Learning could provide optimized critical experiment designs.



The EUCLID project improves upon previous work by incorporating additional types of measurements.

- The use of these experiment types will help constrain nuclear data in previously unachievable ways.
- Our team includes experts in nuclear data, critical/subcritical experiments, machine learning, and MCNP development.
- ML-augmented design balances exploration and exploitation, optimizing the experiment to correct compensating errors.
- Our LDRD reserve provided a design that could increase the mass limit of a PF-4 casting operation by 15%.



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- **Directly Contributing to Important National and International Missions**
- **Making Investments in Pipeline and the Facility for enduring capability and expanding missions**
- **Critical and Subcritical Experiments Fully Operational**
 - Outdoor operations with large quantities of SNM
 - Fission chambers, radiography and other measurement capabilities



Acknowledgements

NCERC is supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

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NCERC Supports Government Programs and Missions

- **Nuclear Criticality Safety Program (NCSP)**
- **National Technical Nuclear Forensics (NTNF)**
- **Nuclear Weapons Stockpile Stewardship Program**
- **Nuclear Material Management**
- **Nuclear Emergency Response**
- **Nuclear Counter-terrorism**
- **Nuclear Nonproliferation / Safeguards / Arms Control**
- **DHS/DNDO, DTRA, NASA, Naval Reactors**
- **Other collaborations: Universities, commercial partners**
- **International collaborations: United Kingdom (AWE), France (IRSN, CEA), Japan (JAEA)**

